

PROCEEDINGS OF SPIE

***Sensors, and Command, Control,  
Communications, and  
Intelligence (C3I) Technologies  
for Homeland Security, Defense,  
and Law Enforcement  
Applications XVI***

**Edward M. Carapezza**  
*Editor*

**10–11 April 2017**  
**Anaheim, California, United States**

*Sponsored and Published by*  
SPIE

**Volume 10184**

Proceedings of SPIE 0277-786X, V. 10184

SPIE is an international society advancing an interdisciplinary approach to the science and application of light.

Sensors, and Command, Control, Communications, and Intelligence (C3I) Technologies for Homeland Security,  
Defense, and Law Enforcement Applications XVI, edited by Edward M. Carapezza, Proc. of SPIE Vol.  
10184, 1018401 · © 2017 SPIE · CCC code: 0277-786X/17/\$18 · doi: 10.1117/12.2281303

Proc. of SPIE Vol. 10184 1018401-1

The papers in this volume were part of the technical conference cited on the cover and title page. Papers were selected and subject to review by the editors and conference program committee. Some conference presentations may not be available for publication. Additional papers and presentation recordings may be available online in the SPIE Digital Library at SPIEDigitalLibrary.org.

The papers reflect the work and thoughts of the authors and are published herein as submitted. The publisher is not responsible for the validity of the information or for any outcomes resulting from reliance thereon.

Please use the following format to cite material from these proceedings:

Author(s), "Title of Paper," in *Sensors, and Command, Control, Communications, and Intelligence (C3I) Technologies for Homeland Security, Defense, and Law Enforcement Applications XVI*, edited by Edward M. Carapezza, Proceedings of SPIE Vol. 10184 (SPIE, Bellingham, WA, 2017) Seven-digit Article CID Number.

ISSN: 0277-786X

ISSN: 1996-756X (electronic)

ISBN: 9781510608696

ISBN: 9781510608702 (electronic)

Published by

**SPIE**

P.O. Box 10, Bellingham, Washington 98227-0010 USA

Telephone +1 360 676 3290 (Pacific Time) · Fax +1 360 647 1445

SPIE.org

Copyright © 2017, Society of Photo-Optical Instrumentation Engineers.

Copying of material in this book for internal or personal use, or for the internal or personal use of specific clients, beyond the fair use provisions granted by the U.S. Copyright Law is authorized by SPIE subject to payment of copying fees. The Transactional Reporting Service base fee for this volume is \$18.00 per article (or portion thereof), which should be paid directly to the Copyright Clearance Center (CCC), 222 Rosewood Drive, Danvers, MA 01923. Payment may also be made electronically through CCC Online at [copyright.com](http://copyright.com). Other copying for republication, resale, advertising or promotion, or any form of systematic or multiple reproduction of any material in this book is prohibited except with permission in writing from the publisher. The CCC fee code is 0277-786X/17/\$18.00.

Printed in the United States of America.

Publication of record for individual papers is online in the SPIE Digital Library.

**SPIE. DIGITAL  
LIBRARY**

[SPIEDigitalLibrary.org](http://SPIEDigitalLibrary.org)

---

**Paper Numbering:** *Proceedings of SPIE* follow an e-First publication model. A unique citation identifier (CID) number is assigned to each article at the time of publication. Utilization of CIDs allows articles to be fully citable as soon as they are published online, and connects the same identifier to all online and print versions of the publication. SPIE uses a seven-digit CID article numbering system structured as follows:

- The first five digits correspond to the SPIE volume number.
- The last two digits indicate publication order within the volume using a Base 36 numbering system employing both numerals and letters. These two-number sets start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B ... 0Z, followed by 10-1Z, 20-2Z, etc. The CID Number appears on each page of the manuscript.

# Contents

v	<i>Authors</i>
vii	<i>Conference Committee</i>

---

## COMMAND, CONTROL SYSTEMS, AND TECHNOLOGIES

---

10184 08	<b>Counter unmanned aerial system testing and evaluation methodology</b> [10184-7]
10184 09	<b>Maximizing PPV in C3I systems</b> [10184-8]
10184 0A	<b>Emergency positioning system accuracy with near infrared LEDs in high-security facilities</b> [10184-9]

---

## COUNTER SHOOTER SYSTEMS AND TECHNOLOGIES

---

10184 0D	<b>Employing wavelet-based texture features in ammunition classification</b> [10184-12]
10184 0E	<b>AFRL Commander's Challenge 2015: stopping the active shooter</b> [10184-13]
10184 0F	<b>Airborne DoA estimation of gunshot acoustic signals using drones with application to sniper localization systems</b> [10184-14]

---

## CYBER SECURITY SYSTEMS AND TECHNOLOGIES

---

10184 0G	<b>Approximating centrality in evolving graphs: toward sublinearity</b> [10184-16]
10184 0H	<b>Vulnerability survival analysis: a novel approach to vulnerability management</b> [10184-17]

---

## SURVEILLANCE, NAV SYSTEMS, AND TECHNOLOGIES I

---

10184 0K	<b>Novel procedure for characterizing nonlinear systems with memory: 2017 update</b> [10184-20]
10184 0M	<b>Hybrid on-chip microwave photonic signal processor architecture</b> [10184-22]

---

## SURVEILLANCE, NAV SYSTEMS, AND TECHNOLOGIES II

---

10184 0Q	<b>Estimating distance to an object on the horizon using wave motion</b> [10184-25]
10184 0R	<b>Advanced wireless mobile collaborative sensing network for tactical and strategic missions</b> [10184-26]

- 10184 OS     **Real-time implementations of acoustic signal enhancement techniques for aerial based surveillance and rescue applications** [10184-27]

---

**SURVEILLANCE, NAV SYSTEMS, AND TECHNOLOGIES III**

---

- 10184 OU     **Finite element method framework for RF-based through-the-wall mapping** [10184-29]
- 10184 OV     **Demonstration of an RF front-end based on GaN HEMT technology** [10184-30]
- 10184 OY     **Battlefield applications of anemometers** [10184-33]

---

**SURVEILLANCE, NAV SYSTEMS, AND TECHNOLOGIES IV**

---

- 10184 OZ     **Inverse determination of heat flux into a gun barrel using temperature sensors** [10184-34]
- 10184 IO     **Overview of Raman spectroscopy techniques for explosive detection** [10184-35]
- 10184 IJ     **Capturing a commander's decision-making style** [10184-37]

---

**POSTER SESSION**

---

- 10184 IK     **A calibration method of non-orthogonal redundant ring laser gyro inertial navigation system** [10184-38]
- 10184 IL     **High-accuracy self-calibration method for dual-axis rotation-modulating RLG-INS** [10184-39]
- 10184 IM     **Online calibration technique for LDV in SINS/LDV integrated navigation systems** [10184-40]

# Authors

Numbers in the index correspond to the last two digits of the seven-digit citation identifier (CID) article numbering system used in Proceedings of SPIE. The first five digits reflect the volume number. Base 36 numbering is employed for the last two digits and indicates the order of articles within the volume. Numbers start with 00, 01, 02, 03, 04, 05, 06, 07, 08, 09, 0A, 0B...0Z, followed by 10-1Z, 20-2Z, etc.

Ambacher, Oliver, 0V	Sandli, Mathias F., 0S
Apolinário, José A., Jr., 0D, 0F	Santos, Eugene, Jr., 12
Birch, G., 08	Shao, Zhili, 0S
Bishop, Steven, 0Q	Smith, Brandon, 0E
Bober, Tomas, 0Y	Spears, Anthony, 0Q
Boghra, Pedram, 09	Stautland, Thomas Kristoffer, 12
Boparai, Ramnjit, 12	Sullivan, John, 0H
Borzino, Ângelo M. C. R., 0D	Swartz, Pete, 0E
Boston, Jonathan, 0E	Ture, Erdin, 0V
Campos, Rafael Saraiva, 0U	Veenhuis, Luke, 12
Crownover, Robin, 10	Walker, Owens, 0A
Cybenko, George, 0G, 0H	Wang, Qi, 13, 14, 15
de Campos, Marcello Luiz R., 0D, 0U	Wang, Qun, 14
Doremus, Steven, 10	Wang, Wenjian, 09
Farris, Katheryn A., 0H	Wei, Guo, 13, 14, 15
Fernandes, Rigel P., 0F	Whitney-Rawls, Amy, 0E
Gao, Chunfeng, 13, 14, 15	Woo, B., 08
Holthe, Aleksander, 0S	Xu, Hao, 0R
Hughes, Derke R., 0K	Xu, L., 0M
Hülsmann, Axel, 0V	Ying, Zhihui, 13
Hunt, Walter, 0Q	
Jablonski, Jonathan A., 0Z	
Jablonski, Melissa N., 0Z	
Jannson, Tomasz, 09	
Katz, Richard A., 0K	
Kim, Keumjoo, 12	
Knoch, Sierra N., 0A	
Koch, Robert M., 0K	
Kostrzewski, Andrew, 09	
Kouhestani, C., 08	
Li, Y., 0M	
Long, Xingwu, 13, 14, 15	
Lovisolo, Lisandro, 0U	
Magin, Jonathan, 0E	
Maier, Robert C., 0D	
Martinez Calderon, Julian, 0E	
McIntire, John P., 0E	
Musser, Markus, 0V	
Nelson, Charles, 0A	
Nguyen, Hien, 12	
Nuttall, Albert H., 0K	
Patel, Darsan, 0Q	
Priest, Benjamin W., 0G	
Quay, Rüdiger, 0V	
Ramos, António L. L., 0F, 0S	
Recchia, Thomas, 0Y	
Rodriguez, J., 0M	
Raphael, David, 0Y	
Russell, Jacob, 12	



# Conference Committee

## *Symposium Chair*

**Donald A. Reago Jr.**, U.S. Army Night Vision & Electronic Sensors  
Directorate (United States)

## *Symposium Co-chair*

**Arthur A. Morrish** Raytheon Space and Airborne Systems  
(United States)

## *Conference Chair*

**Edward M. Carapezza**, EMC Consulting, LLC (United States)

## *Conference Program Committee*

**George Cybenko**, Thayer School of Engineering at Dartmouth  
(United States)

**Panos G. Datskos**, Oak Ridge National Laboratory (United States)

**Gregory L. Duckworth**, BBN Technologies, a Raytheon Company  
(United States)

**Susan F. Hallowell**, Transportation Security Laboratory (United States)  
and Department of Homeland Security (United States)

**Todd M. Hintz**, Space and Naval Warfare Systems Command  
(United States)

**Myron E. Hohil**, U.S. Army Armament Research, Development and  
Engineering Center (United States)

**Ivan Kadar**, Interlink Systems Sciences, Inc. (United States)

**Pradeep K. Khosla**, University of California, San Diego (United States)

**Daniel Lehrfeld**, Blue Marble Group LLC (United States)

**Tariq Manzur**, Naval Undersea Warfare Center (United States)

**Jordan Wexler**, Raytheon Applied Signal Technology, Inc.  
(United States)

## *Session Chairs*

### 1 Non-Lethal Systems and Technologies

**David B. Law**, Joint Non-Lethal Weapons Directorate (United States)

**Myron E. Hohil**, U.S. Army Armament Research, Development and  
Engineering Center (United States)

- 2 Command, Control Systems, and Technologies  
**David B. Law**, Joint Non-Lethal Weapons Directorate (United States)  
**Myron E. Hohil**, U.S. Army Armament Research, Development and Engineering Center (United States)
- 3 Counter Shooter Systems and Technologies  
**Panos G. Datskos**, Oak Ridge National Laboratory (United States)  
**Tariq Manzur**, Naval Undersea Warfare Center (United States)
- 4 Cyber Security Systems and Technologies  
**George Cybenko**, Thayer School of Engineering at Dartmouth (United States)
- 5 Surveillance, Nav Systems, and Technologies I  
**Tariq Manzur**, Naval Undersea Warfare Center (United States)  
**David B. Law**, Joint Non-Lethal Weapons Directorate (United States)
- 6 Surveillance, Nav Systems, and Technologies II  
**Panos G. Datskos**, Oak Ridge National Laboratory (United States)  
**Myron E. Hohil**, U.S. Army Armament Research, Development and Engineering Center (United States)
- 7 Surveillance, Nav Systems, and Technologies III  
**Panos G. Datskos**, Oak Ridge National Laboratory (United States)  
**Myron E. Hohil**, U.S. Army Armament Research, Development and Engineering Center (United States)
- 8 Surveillance, Nav Systems, and Technologies IV  
**Myron E. Hohil**, U.S. Army Armament Research, Development and Engineering Center (United States)  
**Panos G. Datskos**, Oak Ridge National Laboratory (United States)